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ASSESSMENT OF DEPOSITS ON ENGINE HEAD IN SINGLE CYLINDER DIESEL ENGINE

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Abstract

The purpose of this experimental work is to examine deposit accumulations on engine heads by employing a single-cylinder water-cooled diesel engine. In this study, the tested fuels selected are DF, DF95UCO5, and DF65UCO20Pn15. Because it has the largest fuel oxygen percentage, the lowest cetane number, DF65UCO20Pn15, has the longest explosion delay and the shortest burning time. Measurements were made of engine heads and compared to emulsion fuels. The same locations also saw the application of scanning electron microscopy for a qualitative investigation. The investigation's conclusions were supported by visual inspection, which showed some deposition on engine heads while using all fuels. The study found that DF95UCO5 formed more carbon deposits on the engine head than DF65UCO20Pn15 and DF when SEM and EDS were used.

Keywords: *Engine head, Used cooking oil,1-pentanol.*

Introduction

The fast depletion of fossil fuels has prompted research and development on renewable biofuel alternatives. It is discovered that spent cooking oil in this situation can take the place of fossil fuels as an energy source [1]. The oil has drawn interest because of its qualities, which are remarkably similar to those of diesel [2–3]. WCO oil shouldn't be utilized straight away because it might lead to issues including stuck piston rings, blocked injectors, carbon buildup in the combustion chamber, and uneven fuel burning [4-5]. Global energy demand is rising rapidly due to the trend of industrialization and modernization picking up speed. Most emerging countries purchase crude oil to meet increasing energy demands [6]. Both the global depletion of fossil fuel supplies and the pollution caused by exhaust emissions are increasing at the moment. Promote the development of biofuels and other renewable energy sources to replace diesel fuel [7] progressively. A study found that while cooking or frying, waste cooking oil (WCO) is created in large quantities all over the world [8]. The Food and Agricultural Organization's study [9] estimates that the food processing sector in India produces about 23 million tonnes of used cooking oil yearly. Concerns about the environment raised by the disposal of waste cooking oil (WCO) have also increased, prompting calls for its reuse or ingestion in conjunction with financial incentives [10]. When compared to conventional petroleum diesel, SVO has higher viscosity and lower volatility, which is the main cause of these problems [11–12]. The viscosity of plant oil is reduced using chemical or heat procedures in order to restore its properties. Transesterification, microemulsion, dilution, and pyrolysis are a few of these chemical processes. In the thermal process, viscosity is reduced by warming the fuel [13-14]. The most common method for turning vegetable oil into biodiesel nowadays is transesterification. Unfortunately, the energy requirements and processing time for biodiesel purification utilizing this approach are high. After all is said and done, glycerol is another byproduct. There is around 1 kilogram of glycerol produced for every 10 kg of biodiesel. Particularly in small- or medium-sized biodiesel businesses, crude glycerol is usually disposed of due to the expensive purification process [15]. However, glycerol disposal that is not done correctly may harm the ecosystem [16]. Heat treatment has been tried to reduce the viscosity of the vegetable oil (palm oil). The heating of vegetable oil before use clearly reduces its viscosity to a degree similar to that of petroleum diesel [17]. The requirement for alternative fuel sources has forced regulators, engine makers, and searchers to adhere to stringent regulations on engine emissions and the depletion of fossil fuels [18]. Energy-saving methods that might be developed to reduce environmental pollution include exhaust gas recirculation (EGR) and waste heat recovery systems based on thermodynamic cycles, to name a few [19- 20]. There are several fuel options, such as LPG, CNG, biodiesel, bioethanol, and others, to satisfy the growing need for fuels and methods to lower greenhouse gas emissions [21]. The main reasons for low volatility, poor atomization, and deposit development on the injectors, piston grooves, and other combustion chamber components are thought to be high surface tension, kinematic viscosity, and high density [22]. Therefore, it is believed that the three characteristics of high density, high surface tension, and kinematic viscosity must be lessened to use vegetable oils directly in compression ignition engines [23]. While alternative approaches, such as mixing with petroleum diesel oil or adding chemicals, are also employed, heating is considered the most straightforward solution to address the aforementioned shortcomings of vegetable oils [24]. Inefficient combustion of the air-fuel combination and saturated bonds is a major factor in deposit accumulations [27–28]. Deposits start to accumulate on the coldest part of the injector, the combustion chamber nose, and proceed to the chamber wall, piston rings, and cylinder head [29–30]. The fuel injectors of a 33-kW diesel engine that ran on a variety of straight vegetable oils and diesel fuel were tested by D'Alessandro et al. [31]. This investigation intended to evaluate deposit formation on the engine head using DF, DF95UCO5, and DF65UCO20Pn15. **MATERIALS AND METHODS**

A direct-injection diesel engine with compression ignition was proposed. Table 1 shows the configurations of the engines. The reliability test was run on three test fuels, DF, DF95UCO5, and DF65UCO20Pn15, for 200 hours at 1300 rpm and 1 N m load, respectively. Figure 1 shows a schematic diagram of the engine test rig.

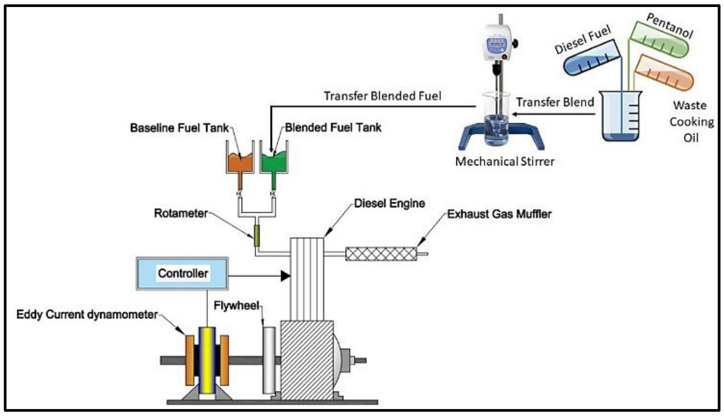

Figure 1Investigational setup of engine test.

The used cooking oil was provided for collection by the adjacent restaurant. When frying chips in oil, temperatures typically range from 130 to 180 degrees Celsius. The UCO was heated and filtered to remove any water particles or suspended food before combining. This process was used to improve blend stability because diesel is water-repellent and the presence of water could lead to phase separation. The properties of used cooking oil, diesel, and n-pentanol are all shown in Table 2.

Table 1Engine specification

During a 200-hour endurance test, every fuel sample was used. The engine head was then taken out after the engine was dismantled. This process was then performed for the other test fuels. SEM and EDS were used to analyze every engine head sample collected in this way. Deposits both large and small are examined using SEMs. It is able to evaluate small deposits for elements using EDS. At 0 h (Fresh) and 200 h (Endurance test), pictures of the engine head were taken of every fuel sample.

[1] **Model**	[2] **Single-Cylinder CIDI Engine**
[3] Bore	[4] 75mm
[5] Compression ratio	[6] 21-23
[7] Displacement	[8] 0.353L
[9] Output (12 hours rating)	[10] 4.4kW/2600r/min
[11] Injection pressure	[12] 14.2 + 0.5 MPa (145+5kg/cm^2)
[13] Valves clearance	[14] Inlet valve 0.15-0.25mm
[15] Governor type	[16] Mechanical. All speed and centrifugal-type
[17] Stroke	[18] 80mm
[19] Injection Pressure	14.2 + 0.5 MPa

Table 2Fuel characterization.

[20] **Properties**	[21] **Diesel Fuel**	[22] **Waste Cooking oil**	[23] **N-pentanol**
[24] Viscosity Cst at 40 ^{0}C	[25] 2.28	[26] 52	[27] 2.89
[28] Density g/ml	[29] 835	[30] 900	[31] 814.4
[32] Flash Point ^{0}C	[33] 78	[34] 279	[35] 49
[36] Oxygen (wt %)	[37] 0	[38] 20	[39] 8.47
[40] Calorific Valve MJ/Kg	[41] 42.5	[42] 37.68	[43] 34.75
[44] Cetane Number	[45] 50	[46] 54	[47] 20

RESULTS AND DISCUSSION

A. *Engine head deposition*

The main parts of diesel engines experience high temperatures and mechanical stresses. Additionally, deposits are formed on these parts due to incomplete or pyrolysis combustion, oxidative and thermal lubricant deterioration, and lubricant degradation. In addition to increasing maintenance costs, these deposits lower engine performance, efficiency, and operation. Significant deposits may potentially lead to engine failure [32]. Carbon is a byproduct that is created when fuel is burned. Carbon deposition is caused by both incomplete fuel combustion and small amounts of pollutants from lubricating oil. The accumulation shortens the engine's service life. [33]. For this inquiry, the carbon deposits on engine heads were photographed and assessed. In the instance of DF95UCO5 compared to petroleum diesel, Figures 4 and 5 show that a thick carbon deposit was found on the engine head that was utilized with damp and unclean. Deterioration and lighter fraction fuel content evaporation may be combined to cause this. The engine powered by DF65UCO20Pn15 has a lower carbon deposit. Less deposition of DF65UCO20Pn15 cleaner may be caused by its burning in the presence of higher oxygen concentrations. During an endurance test, the engine head is seen in Figure 2 in a tilted perspective while operating at different engine operating hours and with different fuels. Just looking at engine heads utilizing different fuels made it hard to tell them apart. Carbon deposits were visually inspected on key engine components. Throughout the trials, the engine ran at the same speed and load, maintaining power output. Before and after operations, pictures of the engine head were taken with a DSLR to compare the carbon deposits. It was also discovered that the engine head's exterior while using DF95UCO5 mixes was dirtier than when using DF. Figure 3 shows the carbon deposits produced when the remaining heat from the engine head polymerizes this leftover gasoline and mixes it with oxygen. When DF95UCO5 was put on the gasoline engine head, figure 4 shows from SEM images that the carbon deposit was thicker than that of DF. High-temperature failures, unburned materials, and sticky components might all be the cause of this. A little layer covered the engine head in the deposition. Due to the fuel's oxygen concentration, DF65UCO20Pn15 however, produces some improved outcomes as shown in figure 5.

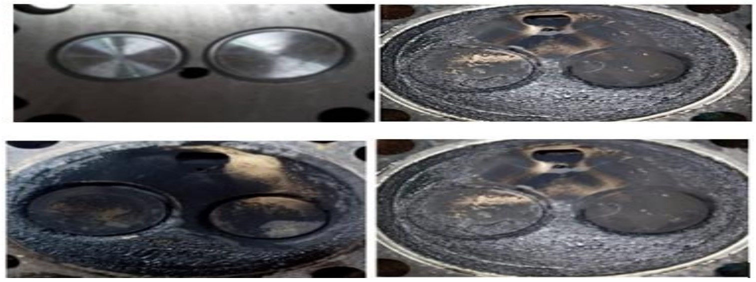

Figure 2 Before using DF and blend mix fuels.

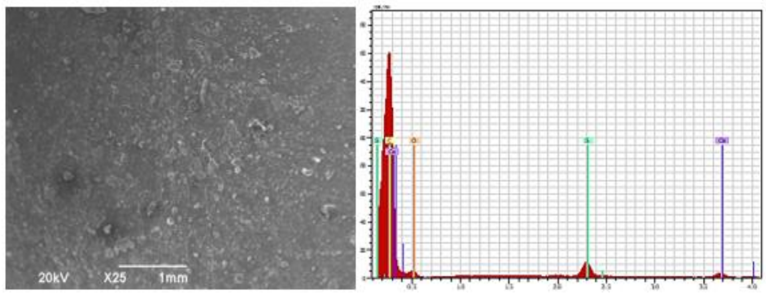

Figure 3 SEM and EDS Analysis of DF100 fuel.

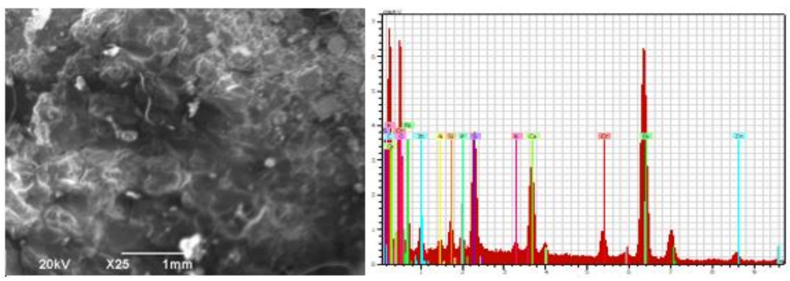

Figure 4 SEM and EDS Analysis of DF95UCO5 blend.

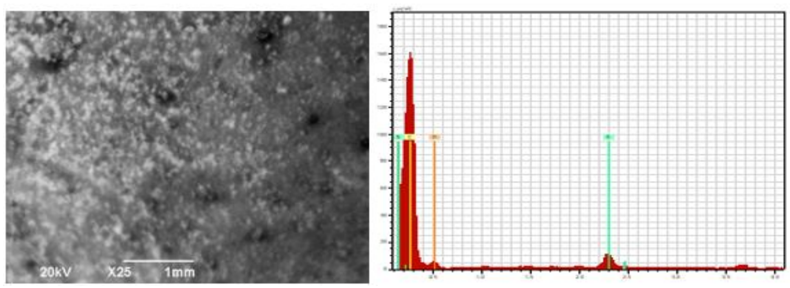

Figure 5 SEM and EDS Analysis DF65UCO20Pn15 blend.

CONCLUSION

D Petroleum diesel fuel was used as a reference fuel in the current study project to examine its impacts. The investigation was conducted using the two test fuels that were left, DF95UCO5 and DF65UCO20Pn15. Each fuel sample's deposit development on engine heads was examined. The experiment might provide the following probable outcomes:

- On all test fuels (DF, DF95UCO5, and DF65UCO20Pn15), deposits were seen on the engine head operating. DF95UCO5 engine head was determined to be dirtier than DF, but DF65UCO20Pn15 was shown to be superior to both.
- Following the 200-hour endurance test, SEM and EDS examination revealed that engine head deposits were much lower with DF65UCO20Pn15 than DF95UCO5. Patchy carbon deposits were found. On the other hand,

DF95UCO5-fueled engines have a smaller engine head and thick, overlapping deposits at the engine head outlet. Concentrations of carbon rose over the whole deposited layer.

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Conflict of Interest

There is no conflict of interest between all the authors

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